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MEASURING SLEEP BY WRIST ACTIGRAPH

ANNUAL REPORT

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Current results now allow us to specify design criteria for a miniaturized wrist-mounted activity monitor suitable for field or combat use.

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SUMMARY

A convenient method of monitoring personnel sleep and activity in field conditions is needed to promote medical planning for modern combat.

In the period from April 1980-March 1981, we have programmed, tested, and begun evaluations of a wearable digital activity system, and we have refined a computer process for recognizing sleep from this system. Together, these efforts enable us to collect data from freely ambulatory subjects which can be scored automatically for sleep/wake with accuracy comparable to EEG scoring. The system is ready for miniaturization leading to field use.

Our microprocessor-based digital activity monitor was built to our specifications, and we added external activity and illumination transducers. Actual data collection was implemented and 25 records totalling over 27,000 minutes have been obtained as of March, 1981. Fourteen records (12,739 minutes) collected with the digital monitor were scored retrospectively with 93.6% agreement with EEG sleep/wake scoring. Research is continuing to further increase the accuracy of the sleep recognition algorithm. Since the errors that occur include both mis-scoring sleep as wake and vice versa, they tend to cancel. Correlations between sleep durations scored from activity data and from EEG records were $r=.9760$ for digital monitor data.

Current results now allow us to specify design criteria for a miniaturized wrist-mounted activity monitor suitable for field or combat use.

FORWORD

For the protection of human subjects the investigator has adhered to policies of applicable Federal Law 45CFR46.

INTRODUCTION

Sleep loss and combat fatigue are increasing concerns for the modern army. A future war is likely to be extremely brief and intense, with victory and defeat determined in a few days or weeks. Soldiers using technically sophisticated modern weaponry will have little time for sleep, and plans must be made to enable personnel to perform effectively throughout the duration of a combat of unprecedented intensity. American troops may have to enter combat immediately after airlift to remote parts of the world, and plans must be developed to minimize the effects of jet-lag on personnel performance.

Military medicine therefore needs a practical method of quantifying sleep both to design personnel strategies and for potential monitoring of troops in actual field deployments.

Traditional physiologic methods for monitoring sleep through EEG-EOG-EMG recordings are completely impractical in actual or simulated combat settings, and subjective monitoring has been shown to be unreliable (1). In addition, both physiologic measures and observational methods for measuring sleep are costly, and considerable time is necessary to quantify sleep by scoring polygraph records.

We are developing a wrist activity monitoring technique as a solution to these problems.

Employing Delgado's (2) telemetric activity recording device, Kupfer et al (3) and Foster et al (4,5) described the use of activity data for quantifying sleep and assessing sleep quality in humans. Encouraged by the high correlations between EEG and actigraphic estimates of sleep -- 0.84 and 0.88 in two separate studies (6,7) -- Kripke et al (8) developed a system in which a piezo-ceramic activity transducer worn on a watchband recorded wrist activity onto a Medilog cassette tape recorder worn on a belt. With this transducer, Kripke et al (8) obtained a correlation of 0.98 between sleep duration determined from wrist activity and the EEG in five subjects.

A more exhaustive study of 63 nights of normal subjects and 39 nights in hospital patients with various sleep disorders was conducted under the first year of our contract (DAMD-17-78-C-8040, 1978-1979). All-night recordings of wrist activity, EEG, EMG and EOG were collected simultaneously on a 4-channel cassette. Each minute was scored as either sleep or wake by one rater using only activity data, and a second rater using only EEG-EOG-EMG data. The raters agreed on 94.5% of the minutes (96.3% for non-patients). Estimates of each subject's total sleep time with the two methods were correlated 0.89 (0.95 for non-patients). These results indicate that the wrist actigraphic analog recording contains sufficient information to produce a highly reliable scoring of sleep.

Having shown that sleep can be identified from activity data, we proposed in 1979 to design a 2-part sleep monitoring system. A digital activity monitor, consisting of an activity transducer, microprocessor and digital memory, would be worn on the wrist. A portable readout device, also microprocessor based, would read and reset the monitors, then interpret their data and generate a sleep report.

To realize this design, a first priority was to establish the optimal design, orientation and placement for the activity transducer. We found the piezo-ceramic transducer used in our previous research to be more sensitive than other available transducers and to be adequately omnidirectional. We also found the wrists to be more active than an ankle or the head, and therefore a better site for locating a transducer. The choice of wrists does not seem crucial, but the non-dominant wrist seems slightly superior (e.g., the left wrist).

Having established optimal transducer design characteristics, we turned our attention to digitizing, preprocessing and storing activity data. As reported in our 1979-1980 report, we found that digitizing at 240 Hz and summing every four digital conversions cancelled 60 Hz noise which sometimes contaminates activity recordings. We also found that a preprocessing algorithm which emphasized changes in activity level provided the best data for automatic sleep recognition. Our 1979-1980 report described our approach to empirically developing an algorithm to recognize sleep from digitized activity data. The further refinement of that approach, and its implementation in a wearable system will be described below.

FURTHER PROGRAM DEVELOPMENTS

Method

Data were obtained from subjects participating in studies involving EEG recording during both wake and sleep. A wrist activity transducer signal was sampled during both wake and sleep. The wrist activity transducer signal was sampled by the analog-to-digital (A/D) converter of our laboratory computer system at a conversion rate of 240 Hz. The analog data was digitized and stored as described in our 1979-1980 report, but only the optimal preprocessing transformation selected in that report was used in data analysis. A total of 20 records (13,488 minutes) were analyzed.

Development of the sleep recognition algorithm began with expressions incorporating a weighted sum of combinations of the digital data with potential for discriminating sleep from wake. Specifically, the expression took the form:

$$D = S \times (W_1 T_1 + W_2 T_2 + W_3 T_3 + W_4 T_4 + W_5 T_5 + W_6 T_6)$$

where S was a scale factor, W's were weights, and:

T_1 = the sum of the digital activity values for all 30 2-second data epochs in a minute,

T_2 = the activity value for the single most active epoch,

T_3 = the sum of the activity values in the two most active epochs separated by at least 30 seconds,

T_4 = the sum of the activity values in the most active 8 epochs.

Terms T_5 and T_6 were themselves weighted sums of term T_1 over the preceding 4 and following 2 minutes:

$$T_5 = W_{51} T_{1,i-1} + W_{52} T_{1,i-2} + W_{53} T_{1,i-3} + W_{54} T_{1,i-4}$$

$$T_6 = W_{61} T_{1,i+1} + W_{62} T_{1,i+2}$$

where $T_{1,i-1}$ is the maximal epoch value for the preceding minute, $T_{1,i+1}$ for the following minute, etc.

A minute was scored 'wake' if $D \geq 1.0$. For each given combination of weights, a range of weights (W) and scale factors (S) was substituted into the above expression for each minute, and the resulting sleep/wake score for all minutes. The proportion of minutes for which the automatic score and EEG score agreed was then computed for each scale value, and the maximum agreement served as a retrospective measure of the effectiveness of the weighting. The computer program (Appendix 1) varied the weighting of one term at a time, and searched for the combination of weights which produced the highest agreement.

As preliminary results became available, it became apparent that better agreement was obtained when $W_1 = W_3 = W_4 = 0$, i.e., the maximal epoch value in each minute was the best discriminator of sleep and wake. This unexpected result was extremely fortunate, since it permitted reducing the data required for sleep scoring by an order of magnitude compared to our prior expectation. We had expected that all 2-second epoch values for each minute would have to be stored.

Accordingly, a second expression was developed:

$$D = S \times (W_1 T_{2,i-4} + W_2 T_{2,i-3} + W_3 T_{2,i-2} + W_4 T_{2,i-1} + W_5 T_{2,i} + W_6 T_{2,i+1} + W_7 T_{2,i+2})$$

where W's represent weights and $T_{2,i}$ represents the maximal epoch value (T_2 in the previous expression) for the current minute, $T_{2,i-1}$ for the previous minute, $T_{2,i+1}$ for the succeeding minute, etc. Again, the computer varied the weighting and compared the resulting sleep/wake score with the EEG score until maximal agreement was obtained.

Seventeen of the 20 records were used in the algorithm development phase described above. The remaining three records were scored prospectively, i.e. each of the three records was scored individually with the single weighting and scale factor found optimal in the development phase. In this test, the laboratory computer simulated the actual deployment of an automatic sleep scoring system, with the results compared to EEG scoring.

Results

The optimal algorithm reached after analysis of the 17 records was:

$$D = .025 \times (.15T_{2,i-4} + .15T_{2,i-3} + .15T_{2,i-2} + .08T_{2,i-1} + .21T_{2,i} + .12T_{2,i+1} + .13T_{2,i+2})$$

where $T_{2,i}$ represents the maximal epoch value in minute i , etc. If $D \geq 1.0$, the minute was scored 'wake', otherwise 'sleep'. The best retrospective agreement between sleep/wake scored automatically with this algorithm and scoring from

EEG records was 94.46% -- that is, 94.46% of all minutes from the 17 subjects were in agreement with the 'true' sleep/wake score. Agreement scores and the proportion of the record scored as sleep by EEG and by the automatic algorithm for each individual subject are shown in Table 1. Again, it should be noted that this is retrospective agreement, the data for these individuals already having been used to select the optimal algorithm.

The ability of this algorithm to score sleep/wake prospectively was tested with the remaining three records. For these records, only the single expression found optimal in the algorithm development phase was chosen prospectively to automatically score sleep/wake. Overall agreement of these three records with EEG scoring was 96.02%. Agreement and the proportion of each individual record scored sleep by both procedures is also shown in Table 1.

In order to understand the remaining shortcomings of the automatic sleep/wake scoring algorithm, data for all minutes mis-scored were listed and compared with the paper record. In general, the conditional probability of mis-scoring wake as sleep was higher (.062) than mis-scoring sleep as wake (.039). A major reason for the higher probability of mis-scoring wake was the tendency of some subjects to lie in bed quietly for up to half an hour before falling asleep, while generating alpha-frequency EEG. On the other hand, while most examples of mis-scoring sleep were due to the presence of activity during sleep, the source of error in these cases was not so much a failure of the actigraphic scoring concept as a problem with the 1-minute scoring epoch chosen for this study. Many of the 'activity during sleep' errors actually represented arousals, but the EEG record showed that the period of wakefulness was less than the one-half minute required to score a 1-minute epoch as wake.

Since mis-scoring occurred in both directions, the estimates of total sleep duration were better than might be inferred from the minute-by-minute agreement figures. The correlation coefficient between the proportion of the record scored as sleep automatically from activity and as hand-scored from EEG were $r=0.9889$ (for the 17 records scored retrospectively) and $r=0.9982$ (for the 3 prospective records). Thus, the automatic scoring represents the relative duration of sleep extremely accurately. Since sleep duration is the dimension of sleep most crucial to sustaining performance, we feel that the automatic sleep recognition procedure described here represents a very effective scoring technique.

A further test conducted with these data sought to determine the resolution in the stored data necessary to achieve these levels of accuracy. The digital activity value was stored on disk as a 16-bit word, i.e. a number in the range of 0-32767. To investigate the resolution requirement, the sleep recognition program was repeated with the same data, but the resolution was reduced by dividing by powers of 2 and truncating. There was no decrease in agreement with 4-bit data (0-15) and a decrease of only 0.1% with 3-bit data (0-7). This surprising result is important, since it means that more data can be stored in a given memory capacity of the wearable activity monitor, providing appropriate scale factors are chosen.

TESTING THE DIGITAL ACTIVITY MONITOR

In our original proposal to produce a wearable digital activity monitor, we suggested a design in which the signal from a piezo-ceramic activity transducer would be entered through an analog-to-digital converter into an IM6100 microprocessor, and the processed activity values stored in random-access memory. All electronic components of this proposed system would be CMOS for minimal power consumption.

As noted in our 1979-1980 Annual Report, we found that these components could be assembled by the Vitalog Corporation*. After extensive discussions with Vitalog, we ordered a prototype monitor consisting of an IM6100 microprocessor, IM6001 Parallel Interface Element, 6K x 12 RAM memory, 512 word EPROM memory, 8-channel A/D converter, crystal clock and an LED indicator light. The unit is powered by rechargeable 5.6 volt batteries. It is enclosed in a 15 cm x 9 cm x 5½ cm plastic case. Vitalog also provided an interface between the monitor and our Apple microcomputer.

After receiving the monitor, we designed and built an external transducer incorporating a piezo-ceramic element, a photocell, a battery and amplification circuitry necessary to match the A/D input requirements. (The photocell was included to permit an objective measure of "lights out" and "lights on" and potentially to investigate sleep onset latency.) This external transducer, 7 cm x 4 cm x 2 cm, is worn on a wrist band like a watch. It is attached to the monitor by a cable. A schematic diagram of the transducer circuitry is presented as Figure 1.

Having assembled and tested the monitor system, we began by investigating its technical capabilities. One very important technical consideration was the useful life of the battery charge, since this limits the duration of a recording session. Battery drain was found to be 3.4 mA when the processor was halted and 8.5 mA when running. Since in most applications the processor is idling much of the time, a third state (WAIT) can be entered which keeps the processor running, but not executing instructions, at a drain of about 5.2 mA. The battery life was found to be 70 hours at 8.5 mA (running continuously) and 180 hours at 5.2 mA (running with WAIT). We subsequently devised a system for changing batteries without disturbing the recording, removing this limit to recording duration. We also investigated the accuracy of the crystal clock, and found that it lost 1.2 seconds each hour, well within acceptable limits. While considerable improvement in battery life can probably be obtained in any future model, the Vitalog system already demonstrates the feasibility of powering a microprocessor-based wrist activity monitor.

The majority of our effort in preparing the monitor system for use has been in development of a monitor program to direct the collection and storage of activity data. The algorithms for converting the continuous analog signal from the activity transducer to a value representing activity for each minute were equivalent to those discussed above. The monitor program that was ultimately developed, tested, and used to collect digital activity records digitized the signal from the transducer at 240 Hz, and 4 consecutive values were summed to provide a measure of activity free of 60 Hz noise. The sum was then transformed

*Vitalog Corporation, 1056 California Avenue, Palo Alto, CA 94306.

to a difference score, and 120 such scores summed to produce an activity value for each 2-second data epoch. Every minute, the greatest 2-second activity value in that minute was stored. A voltage indicating the illumination level of the photocell was also digitized and stored each minute and a time code was signaled through the LED. The monitor program (Appendix 2) fills 448 memory locations, leaving 5696 locations available for data storage. This allows us to store two 12-bit data words (activity and illumination) each minute for 47 hours and 28 minutes. Since 4-bit resolution would be adequate, up to 6 times this duration or about 12 days sleep data could be stored were the illumination data sacrificed and battery changes feasible.

For test recordings, where it is necessary to compare digital activity records with EEG recordings, the LED was coupled through a receiving photocell to the polygraph to provide a time reference each minute on the polygraph record. The EEG recordings were scored, and both EEG and activity monitor scores were transferred to our laboratory computer system. To date, 25 laboratory recordings totalling over 27,000 minutes have been collected, and 14 have been fully analyzed retrospectively. Results are presented in Table 2. Retrospective agreement of these 14 records (12,739 minutes) is 93.6% with EEG scoring. The correlation coefficient between the proportion of each record scored as sleep by the two techniques is $r=.9760$.

In the final months of our 1980-1981 contract year, we plan to analyze a series of activity-monitored nights with prospective scoring to complete validation of our sleep scoring methodology. In addition, we will prepare a complete technical specification of the methodology from which a microminiaturized monitor wearable entirely on the wrist could be built. Our Vitalog digital monitor is fully programmable and in no way limited by the program described above. Any number of control programs could be written to record activity or illumination data differently and to monitor other functions through the unused A/D channels. These extended capabilities of the instrument can be utilized in our proposed 1981-1982 contract.

CONCLUSION

Mullaney, Kripke and Messin (9) have shown that a trained scorer can score wrist activity data for sleep/wake with accuracy approaching EEG scoring. In the present study, we have shown that wrist activity data can be digitized and scored automatically by computer with no loss in accuracy. Mullaney et al estimated that their activity scoring system was 5 to 10 times less costly than EEG scoring, and that the marginal decrease in accuracy was more than compensated by the greater amount of data that could be collected for a given expense. We feel that the automatic scoring system described here further improves the cost-benefit relationship by replacing the largely mechanical analog recording and playback system, including the polygraph, with an all-digital system. Automatic scoring is accomplished in seconds, eliminating the hours of skilled labor needed for writing out a polygraph record and the many minutes needed for visually scoring the record. Elimination of a scorer further reduces costs and for the first time makes the identification of sleep and wake fully objective, without the many opportunities for error and variability presented by human scoring. We are continuing with further algorithm refinements and testing, but it is unlikely much improvement can be obtained over the current results, nor is much improvement needed.

As of March, 1981, we have completed the major technical goals of our contract. Specifically, we have designed, built, tested, and evaluated a wearable digital activity monitor usable for sleep/wake scoring. Preliminary validation studies (using a retrospective technique) produced a $r=.9760$ correlation of automatic scoring of total sleep duration versus LEG scoring. This far exceeds our 90% design specification. Our technical development has been extremely successful. Judging from our experience with the same algorithm utilized with the laboratory computer, we believe there will be little or no degradation of validity in prospectively scored records, nevertheless, we are completing prospective validation in the remaining months of our 1980-1981 contract. In addition, we will submit an exact technical specification giving hardware and software specifications for a miniaturized microprocessor-controlled activity monitor. With this specification, a miniaturized monitor wearable entirely on the wrist could be designed and produced with currently available technology.

A miniaturized wrist-mounted sleep monitor could be used in field trials or in actual combat to monitor the fatigue and sleep-loss of Army troops.

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Figure 1. Schematic diagram of external activity transducer, photocell and level-matching amplification circuitry

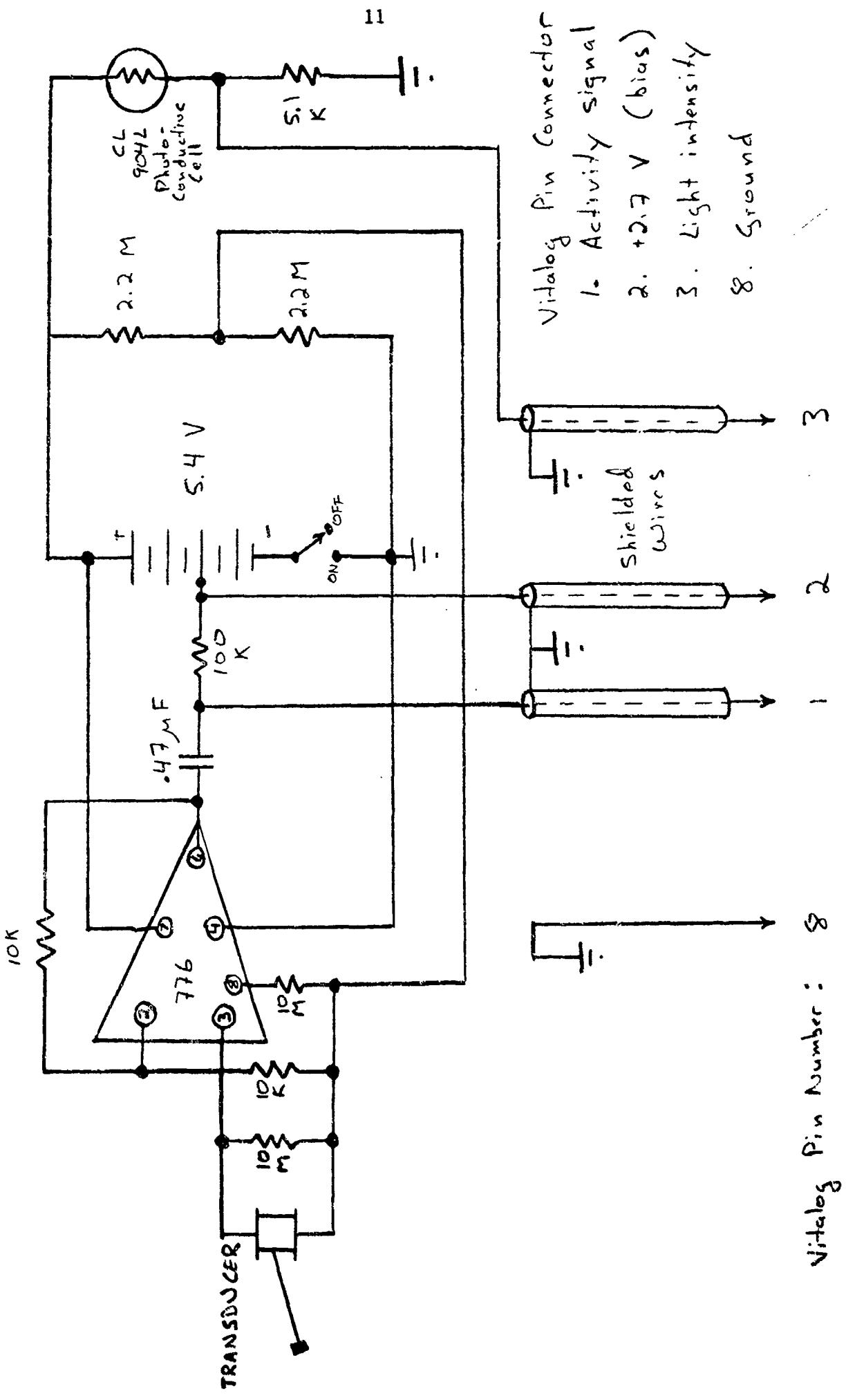


TABLE 1

Subject	Recording Duration (minutes)	% Agreement	% Sleep (EEG)	% Sleep (Act.)
1	353	97.17	0.00	2.83
2	574	96.17	45.47	46.86
3	632	95.89	56.80	59.65
4	903	83.82	29.57	34.33
5	660	97.42	54.55	56.21
6	798	95.36	41.73	44.11
7	845	96.80	37.99	40.95
8	1129	96.19	30.65	31.62
9	644	96.89	50.47	51.40
10	553	88.79	56.06	48.10
11	371	96.77	92.72	95.96
12	527	96.96	14.99	16.13
13	226	89.82	93.81	93.36
14	673	91.98	50.67	45.62
15	593	95.78	56.49	59.36
16	829	91.19	40.17	47.77
17	<u>692</u>	<u>94.08</u>	<u>15.17</u>	<u>20.18</u>
Total				
Retrospective	11002	94.46	42.09	43.98
18	369	93.50	70.19	76.69
19	846	93.62	28.84	31.68
20	<u>1271</u>	<u>98.35</u>	<u>36.82</u>	<u>37.69</u>
Total				
Prospective	2486	96.02	39.06	41.39

Table 1. Record duration, proportion of the record for which hand-scored EEG and automatically scored activity scores agree, and proportion of the record scored as sleep by the two techniques. Total duration and overall proportions for the records scored retrospectively and those scored prospectively are also presented.

TABLE 2

Subject	Recording Duration	% Agreement	% Sleep (EEG)	% Sleep (Act.)
1	366	89.92	85.71	95.80
2	2847	95.67	18.68	20.89
3	1472	97.95	24.27	25.91
4	2848	96.90	20.61	23.42
5	461	90.93	97.35	92.70
6	344	95.52	97.61	97.31
7	465	83.55	88.16	79.61
8	500	91.65	91.85	88.39
9	502	91.89	90.06	85.19
10	487	92.68	96.03	96.65
11	483	94.39	82.70	97.05
12	503	83.20	81.58	93.52
13	1100	92.12	35.47	39.32
14	487	90.17	89.33	98.33
<hr/>				
Total				
Retrospective	12739	93.61	46.38	48.87

Table 2. Record duration, proportion of the record for which hand-scored EEG and automatically scored activity scores agree, and proportion of the record scored as sleep by the two techniques. Total duration and overall proportions are also presented.

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 0035 C AUTHOR: JOHN WEBSTER
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 0037 C VA Medical Center - San Diego
 0038 C Mail Code V-116
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6653 GO TO 150
6654 110 IF (NA.NE.2HVI) GO TO 50
6655 FILE=2HVD
6656 LO=66
6657 LIM=65
6658 WRITE (LU1,125)
6659 125 FORMAT (1, MULTPLY VITALOG SCORE BY:__)
6660 READ (LU1,* XMULT
6661 LO=LO-XMULT*10
6662 LIM=LIM-XMULT*10
6663 150 WRITE (LU1,250)
6664 200 FORMAT (1, NUMBER OF MINUTES FORWARD: --)
6665 READ (LU1,* ) IFW
6666 IFW=IFW+1
6667 WRITE (LU1,250)
6668 250 FORMAT (1, NUMBER OF MINUTES BACKWARD: --)
6669 READ (LU1,* ) IBW
6670 IBW=IBW+IFW+1
6671 IF (IBW.LE.IB) GO TO 350
6672 WRITE (LU1,300)
6673 300 FORMAT (1, 15 MINUTES MAX *** *)
6674 GO TO 150
6675 WRITE (LU1,400)
6676 400 FORMAT (1, ENTER WEIGHTS FOR MINUTE. . ./)
6677 K=0
6678 DO 500 K=1-IBW,IFW
6679 K=K+1
6680 IF (I.GE.0) GO TO 480
6681 WRITE (LU1,470) K,I
6682 470 FORMAT (3X,12,) I-12: --
6683 GO TO 495
6684 480 IF (I.GT.0) GO TO 490
6685 WRITE (LU1,421) K
6686 490 FORMAT (30X,12,) *I*: --
6687 GO TO 495
6688 495 WRITE (LU1,491) K,I
6689 491 FORMAT (30X,12,) I+11: --
6690 495 READ (LU1,* ) W(K)
6691 500 CONTINUE
6692 545 DO 550 I=1,4
6693 550 CONTINUE
6694 NW(I)=J
6695 5105 CONTINUE
6696 5105 WRITE (LU1,560)
6697 5105 FORMAT (1, ENTER UP TO 4 WEIGHTS TO BE 'BRACKETED' : --)
6698 READ (LU1,* ) NW(1),NW(2),NW(3),NW(4)
6699 WRITE (LU1,560)
6700 560 FORMAT (1, )
6701 600 LK=4
6702 IF (NW(4).EQ.0) LK=3
6703 IF (NW(3).EQ.0) LK=2
6704 IF (NW(2).EQ.0) LK=1
6705 IF (NW(1).EQ.0) LK=0
6706 LN=3**LK
6707 DO 760 I=1,1W
6708 CWH(I)=W(I)
6709 760 CONTINUE
6710 775 DO BUG K=1,61
6711 DO CGF J=1,20
6712 DO BUG I=1,4
6713 IPOIK.J,I)=0
6714 800 CONTINUE
6715 IF (LU(3).EQ.1) GO TO 875
6716 IF (LU(3).EQ.3) WRITE (LU0,850)
6717 8115 CONTINUE
6718 8115 CWH(I)=W(I)
6719 8119 775 DO BUG K=1,61
6720 DO CGF J=1,20
6721 DO BUG I=1,4
6722 IPOIK.J,I)=0
6723 8115 CONTINUE
6724 IF (LU(3).EQ.1) GO TO 875
6725 IF (LU(3).EQ.3) WRITE (LU0,850)

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8127   875 DO 4233 10=101,126
8128   IF (HA.EQ.2HVI) GO TO 998
8129   IF (10.EQ.101) GO TO 4260
8130   IF (10.EQ.107) GO TO 4280
8131   IF (10.EQ.108) GO TO 4200
8132   IF (10.EQ.114) GO TO 4200
8133   IF (10.EQ.115) GO TO 4200
8134   IF (10.EQ.117) GO TO 4200
8135   GO TO 950
8136   IF (10.GE.115) GO TO 4200
8137   950 IFILE(3)=KCVT(10)
8138
8139 C READ DATA FILE
8140 C-----
8141 1000 CALL OPEN (IDCB,IER,IBUF,FILE)
8142   IF (IER.LT.0) GO TO 9960
8143   CALL READF (IDCB,IER,IBUF)
8144   IF (IER.LT.0) GO TO 9910
8145   LEN=IBUF*256+IBUF(2)
8146   IL=LEN+2
8147   CALL READF (IDCB,IER,IBUF,IL,JL,-1)
8148   IF (IER.LT.0) GO TO 9920
8149   IF (ILU(3).EQ.1) GO TO 2100
8150   WRITE (ILU,2999) IFILE,LEN
8151   2999 FORMAT (2H ,3A2,18 MINUTES--)
8152
8153 C PROCESS DATA
8154 C-----
8155 2100 DO 4900 I=3,1L
8156   DO 2200 J=1W,2,-1
8157   VECTR(J)=VECTR(J-1)
8158   ISTAT(J)=ISTAT(J-1)
8159   2200 CONTINUE
8160   ISTAT=1
8161   IF (HA.EQ.2HVI) GO TO 2380
8162   IF (IBUF(1).LE.0) IBUF(1)=63
8163   2380 IF (IBUF(1).LT.128) GO TO 2500
8164   IBUF(1)=IBUF(1)-123
8165   ISTAT=0
8166   VECTR=FLOAT(1IBUF(1))*XMULT
8167   IF (VECTR.GT.63) VECTR=63
8168   DO 3900 IZL=1,LN
8169   D=0.
8170   DOT=0.
8171   IF (I>2.LT.IW) GO TO 4980
8172   IF (IW>4).EQ.0) GO TO 3982
8173   CW(CW(4))=W(IW(4))*((IZL-1)/27-1)
8174   3982 IF (CW(3).EQ.0) GO TO 3984
8175   CW(CW(3))=W(IW(3))*((IZL-1)/27-1)
8176   3984 IF (CW(2).EQ.0) GO TO 3986
8177   CW(CW(2))=W(IW(2))*((IZL-1)/27-1)
8178   3986 IF (CW(1).EQ.0) GO TO 3988
8179   CW(CW(1))=W(IW(1))*((IZL-1),3)-1)
8180   3988 IW=0
8181   DO 3940 IZL=1,IW
8182   IW=IW+CW(IZL)
8183   3940 CONTINUE
8184   DO 3750 IZL=1,IW
8185   CW(IZL)=CW(IZL)/IW
8186   3750 CONTINUE
8187   C (DOT) PRODUCT LOOP
8188   2600 DO 2700 K=1,IW
8189   DOT=DOT+VECTR(K)*C(K)
8190   2700 CONTINUE

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C1191 DO 3330 JJ=LO,LIM
C1192 SCALE=JJ/1E3D.
C1193 0=DOT*SCALE
C1194 L=JJ-(LO-1)
C1195 KS=0
C1196 IF (0.GE.1.8) KS=2
C1197 LS=1STAT(KJ)
C1198 KLS=KS+LS+1
C1199 IPO(IZL,L,KLS)=IPO(IZL,L,KLS)+1
C1200 3862 CONTINUE
C1201 3903 CONTINUE
C1202 4062 CONTINUE
C1203 4206 CONTINUE
C1204 4330 NS=IPO(1,1,1)+IPO(1,1,3)+IPO(1,1,4)
C1205 NS=IPO(1,1,1)+IPO(1,1,2)+IPO(1,1,3)+IPO(1,1,4)
C1206 4799 J=1,LN
C1207 IFMAX=G
C1208 DO 4799 J=1,LN
C1209 IFMAX=G
C1210 DO 4680 I=LO,LIM
C1211 L=1-(LO-1)
C1212 NC=IPO(J,L,1)+IPO(J,L,4)
C1213 IFMAX=MAX(NIMAX,NC)
C1214 IF (NIMAX-NC) GO TO 4518
C1215 SMAX=1/10000.
C1216 MAXJ=J
C1217 IF (NMAX-NE.NC) GO TO 4698
C1218 MAXC=NC
C1219 SMAX=1/10000.
C1220 MAXI=L
C1221 46800 CONTINUE
C1222 IF (INW(4).EQ.8) GO TO 4682
C1223 CW(INW(4))=W(INW(4))+((J-1)/27-1)
C1224 4682 IF (INW(3).EQ.8) GO TO 4584
C1225 CW(INW(3))=W(INW(3))+((MOD((J-1),27)/9-1)
C1226 4684 IF (INW(2).EQ.8) GO TO 4685
C1227 CW(INW(2))=W(INW(2))+((MOD((J-1),9)/3-1)
C1228 4686 CW(INW(1).EQ.8) GO TO 4683
C1229 CW(INW(1))=W(INW(1))+((MOD((J-1),3)-1)
C1230 4683 WJ=J
C1231 DC 4685 I=1,10
C1232 WJ=INW+CW(1)
C1233 46850 CONTINUE
C1234 DO 4675 I=1,10
C1235 CX(I)=CW(I)/MW
C1236 4675 CONTINUE
C1237 PC=100*FLOAT(NMAX)/FLOAT(NN)
C1238 IF ((LU((3)).EQ.1)) GO TO 4730
C1239 WRITE (LU(4690), (CW(I), I=1,10), SMAX, PC)
C1240 4690 FORMAT (1H ,1.1F7.4,F7.2)
C1241 4730 CONTINUE
C1242 PS=100*FLOAT(NS)/FLOAT(NN)
C1243 PC=100*FLOAT(NMAX)/FLOAT(NN)
C1244 DO 4850 LN=1,4
C1245 PP(LN)=100*FLOAT(IPC(MAXJ,MAXI,LN))/FLOAT(NN)
C1246 4850 CONTINUE
C1247 IF ((LU(3).EQ.1)) GO TO 4950
C1248 WRITE (LU,4043)
C1249 4048 FORMAT (/,)
C1250 WRITE (LU,4930) PCC,MN,PS,(PP(I),I=1,4)
C1251 4930 FORMAT (/, PERCENT CORRECT: "F6.2" %")
C1252 /* MANTISSAS SCOPED: "15

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4255 4950 IF ((W(4).EQ.0)) GO TO 5002
4256 W(W(4))-W(W(4))+((MAXJ-1)/27)-1)
4257 5002 IF ((W(2).EQ.0)) GO TO 5004
4258 W(W(3))-W(W(3))+((MOD((MAXJ-1),27)/9)-1)
4259 5004 IF ((W(2).EQ.0)) GO TO 5005
4260 W(W(2))-W(W(2))+((MOD((MAXJ-1),9)/3)-1)
4261 5005 IF ((W(1).EQ.0)) GO TO 5006
4262 W(W(1))-W(W(1))+((MOD((MAXJ-1),3)-1))
4263 5006 WRITE (LU0,5010) (W(I),I=1,18),SSMAX,PCC
4264 5010 FORMAT (1H ,10F5.1,F6.3,F6.2)
4265 1F (L1(3),E0.0) GO TO 9050
4266 00 9040 I=1,4
4267 0F (W(1),E0.0) GO TO 9040
4268 1F (W(1)-W(1)+1,E0.0) GO TO 9040
4269 1F (W(1),GT,1W) W(1)=1
4270 9040 CONTINUE
4271 9271 GO TO 606
4272 9272 9050 WRITE (LUI,3089)
4273 9899 FORMAT (1" MORE? : _")
4274 8274 READ (LUI,8899) IANS
4275 8099 FORMAT (A2)
4276 8276 IF (IANS.EQ.2)YE) GO TO 545
4277 9007 STOP 7777
4278 9007 WRITE (LUI,9990) IER
4279 9279 STOP 1
4280 9910 WRITE (LUI,9990) IER
4281 8281 STOP 2
4282 9282 WAIT (LUI,9990) IER
4283 9283 STOP 2
4284 9993 FORMAT (1" ERROR-16" ,* ,*)
4285 9999 END
4286 END
4287 END

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LDP      RUDFD  /SET UP FILE FOR A/D
LDP      CLA 1AC  /START WITH CH.1 (BIAS)
LDP      J15      A20
LDP      CLA      BIAS
LDP      J15      A20
LDP      CLA      BIAS AND SAVE
LDP      J15      THEN CH.0 (ACT)
LDP      CLA      FIND DIFFERENCE
LDP      J15      PAUL INTO BUFFER
LDP      CLA      RESET BUFFER FNTP.
LDP      J15      IF AT END (END)
LDP      CLA      STEND
LDP      J15      .+3
LDP      CLA      STKBEG
LDP      J15      A13
LDP      CLA      PEAKED
LDP      J15      1

LDP      CLA      ANALOG TO DIGITAL CONVERSION
LDP      J15      MULT
LDP      CLA 1AC  /MAN. SELECT
LDP      J15      SET UP BACKUP CHNS
LDP      CLA      MCNT
LDP      J15      MCNTF
LDP      CLA      UPDTE?
LDP      J15      SYRTE2
LDP      CLA      CTR
LDP      J15      NONE
LDP      CLA      MCNT
LDP      J15      .+4
LDP      CLA      YES
LDP      J15      MASK GARBBAGE &
LDP      CLA      EXIT

LDP      CLA      CONSTANTS AND VARIABLES
LDP      J15      MAXEP. 0   /INITIAL CRA VALUE
LDP      CLA      LITE. 0   /HOLDS LITE LEVEL VALUE
LDP      CLA      ACSAVE. 0   /SAVES AC DURING INTRT
LDP      CLA      LKSAVE. 0   /SAVES LK DURING INTRT
LDP      CLA      CRASAV. 0   /SAVES CRA DURING INTRT
LDP      CLA      STKBEG. 547  /POINTS TO ACT SCORE BUFFER
LDP      CLA      ERROR. 0   /INITIAL CRA VALUE
LDP      CLA      RWDRD. 201  /END OF ACT SCORE BUFFER
LDP      CLA      STKEND. 7221  /TIME DELAY FOR A/D
LDP      CLA      MCNT. 7766  /COUNTER FOR TIME DELAY
LDP      CLA      MCNTR. 0   /USED TO MASK A/D CONV
LDP      CLA      X377. 377
LDP      CLA      H5. -6
LDP      CLA      B105. 0   /HOLDS TRANS. EIAS VALUE
LDP      CLA      B105P. 4220  /INITIAL CRB VALUE
LDP      CLA      E115. 0   /POINTS TO START OF RECORDER MEM.
LDP      CLA      D115. 115
LDP      CLA      D115. 115

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0107	0000	MINUT.	0	MINUTE COUNT
0108	125	TCODE.	0	TIME CODE
0109	125	115.	-5	COUNTEP FOR TIME CODE
0110	150	CPSS.	0	
0111	151	CCHTP.	0	
0112	152	115.	-5	
0113	153	TCODE.	0	TIME CODE '0' OF '1'
0114	154	CODE1.	0	TIME CODE FLAG
0115	155	TFLOG.	0	
0116	155	115.	-30	MINUTE DIVIDER
0117	157	MINIV.	0	ACCUMULATES EPOCH SUM
0118	158	EPSSUM.	0	ACCUMULATES DIFSCP SUM
0119	141	DPSSUM.	0	
0120	142	1120.	-120	EPOCH DIVIDEP
0121	147	EP011V.	0	ACCUMULATES SUM TO 4
0122	144	SUM14.	0	
0123	145	114.	-4	ACCOUNTS 4
0124	146	CNT4.	0	MASK FOR DIFSCR
0125	147	1177.	177	
0126	150	XX7700.	770	HOLES DATA PRIOR TO STOP
0127	151	DATAFD.	0	POINTS TO TIME CODE PTN
0128	152	0600	0	CONNECT
0129	153	0400	0	DIFSCR
0130	154	0000	0	POINTS TO DIFSCR PTN
0131	155	1000	0	TEIP CRA STORE
0132	156	2001	1000	CRA TO GET FIELD 1
0133	157	7776	1101	/- END OF FIELD
0134	160	110.	-2	
0135	161	7600	7600	/- END OF FIELD
0136	162	04000.	4000	ACPA TO WAIT
0137	163	LATEST.	0	HOLES MOST RECENT SUM
0138	164	0557	557	POINTS TO DIFSCP BUFFEP
0139	165	0000	0	BUFFER LOC
0140	166	0000	0	
0141	167	0000	0	
0142	170	0000	0	STORES
0143	171	0640	0	POINTS TO STORE PTN
0144	172	0000	0	
0145	173	0000	0	
0146	174	2765	111.	
0147	175	2770	112.	
0148	176	2777	114.	
0149	177	2077	277.	
0151				
0152				
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0215	31CS	EPOCH.	DCA	MINOT
0216	262		DCA	EPSUM
0217	263		DCA	DFSUM
0218	264		TAD	M120
0219	265		DCA	EPDIV
0220	266		DCA	SUM1
0221	267	FOUR.	TAD	M4
0222	268		DCA	CNT4
0223	271		TAD	TELAG
0224	272		SZA	CLA
0225	273		J15	CODETS
0226	274		101	
0227	275	EACH.	CLA	ENTER EACH A/D
0228	276		TAD	A13
0229	277		CIA	
0230	308		TAD	A14
0231	301		SZA	/IS A/D BUFFEP EMPTY?
0232	302		J1P	
0233	303		PCFA	
0234	304		10L	
0235	305		M04	
0236	306		TAD	0.4000
0237	307		LCR1	
0238	310		ACL	
0239	311		LCPI4	
0240	312		HOP	
0241	317		HOP	
0242	314		J1P	NO. READ NEXT VALUE
0243	315		CLA	CLL
0244	316		TAD	A14
0245	317		TAD	SUM4
0246	318		CLA	SUM4
0247	321		TAD	A14
0248	322		TAD	RESET BUFFER IF AT END
0249	323		SZA	STHEND
0250	324		CLA	
0251	325		J1P	.43
0252	326		TAD	STKREG
0253	327		DCA	A14
0254	328		ISZ	SUMED 4 YET?
0255	329		J1P	
0256	330		SUM1	
0257	331		J15	A10
0258	332		101	
0259	333		CLL	
0260	334		TAD	DFSUM
0261	335		S2L	TRUNCATE IF TOO LARGE
0262	347		STA	
0263	348		DCA	ISZ
0264	349		EPDIV	
0265	350		J1P	FOUP
0266	351		TAD	DFSUM
0267	352		CLL	A10
0268	353		CIA	
0269	354		TAD	
0270	355		S2L	
0271	356		STA	
0272	357		DCA	
0273	358		ISZ	
0274	359		EPDIV	
0275	360		J1P	FOUP
0276	361		TAD	DFSUM
0277	362		CLL	A10
0278	363		CIA	
0279	364		TAD	
0280	365		S2L	
0281	366		STA	
0282	367		DCA	
0283	368		ISZ	
0284	369		EPDIV	
0285	370		J1P	FOUP
0286	371		TAD	DFSUM
0287	372		CLL	A10
0288	373		CIA	
0289	374		TAD	
0290	375		S2L	
0291	376		STA	
0292	377		DCA	
0293	378		ISZ	
0294	379		EPDIV	
0295	380		J1P	FOUP
0296	381		TAD	DFSUM
0297	382		CLL	A10
0298	383		CIA	
0299	384		TAD	
0300	385		S2L	
0301	386		STA	
0302	387		DCA	
0303	388		ISZ	
0304	389		EPDIV	
0305	390		J1P	FOUP
0306	391		TAD	DFSUM
0307	392		CLL	A10
0308	393		CIA	
0309	394		TAD	
0310	395		S2L	
0311	396		STA	
0312	397		DCA	
0313	398		ISZ	
0314	399		EPDIV	
0315	400		J1P	FOUP
0316	401		TAD	DFSUM
0317	402		CLL	A10
0318	403		CIA	
0319	404		TAD	
0320	405		S2L	
0321	406		STA	
0322	407		DCA	
0323	408		ISZ	
0324	409		EPDIV	
0325	410		J1P	FOUP
0326	411		TAD	DFSUM
0327	412		CLL	A10
0328	413		CIA	
0329	414		TAD	
0330	415		S2L	
0331	416		STA	
0332	417		DCA	
0333	418		ISZ	
0334	419		EPDIV	
0335	420		J1P	FOUP
0336	421		TAD	DFSUM
0337	422		CLL	A10
0338	423		CIA	
0339	424		TAD	
0340	425		S2L	
0341	426		STA	
0342	427		DCA	
0343	428		ISZ	
0344	429		EPDIV	
0345	430		J1P	FOUP
0346	431		TAD	DFSUM
0347	432		CLL	A10
0348	433		CIA	
0349	434		TAD	
0350	435		S2L	
0351	436		STA	
0352	437		DCA	
0353	438		ISZ	
0354	439		EPDIV	
0355	440		J1P	FOUP
0356	441		TAD	DFSUM
0357	442		CLL	A10
0358	443		CIA	
0359	444		TAD	
0360	445		S2L	
0361	446		STA	
0362	447		DCA	
0363	448		ISZ	
0364	449		EPDIV	
0365	450		J1P	FOUP
0366	451		TAD	DFSUM
0367	452		CLL	A10
0368	453		CIA	
0369	454		TAD	
0370	455		S2L	
0371	456		STA	
0372	457		DCA	
0373	458		ISZ	
0374	459		EPDIV	
0375	460		J1P	FOUP
0376	461		TAD	DFSUM
0377	462		CLL	A10
0378	463		CIA	
0379	464		TAD	
0380	465		S2L	
0381	466		STA	
0382	467		DCA	
0383	468		ISZ	
0384	469		EPDIV	
0385	470		J1P	FOUP
0386	471		TAD	DFSUM
0387	472		CLL	A10
0388	473		CIA	
0389	474		TAD	
0390	475		S2L	
0391	476		STA	
0392	477		DCA	
0393	478		ISZ	
0394	479		EPDIV	
0395	480		J1P	FOUP
0396	481		TAD	DFSUM
0397	482		CLL	A10
0398	483		CIA	
0399	484		TAD	
0400	485		S2L	
0401	486		STA	
0402	487		DCA	
0403	488		ISZ	
0404	489		EPDIV	
0405	490		J1P	FOUP
0406	491		TAD	DFSUM
0407	492		CLL	A10
0408	493		CIA	
0409	494		TAD	
0410	495		S2L	
0411	496		STA	
0412	497		DCA	
0413	498		ISZ	
0414	499		EPDIV	
0415	500		J1P	FOUP
0416	501		TAD	DFSUM
0417	502		CLL	A10
0418	503		CIA	
0419	504		TAD	
0420	505		S2L	
0421	506		STA	
0422	507		DCA	
0423	508		ISZ	
0424	509		EPDIV	
0425	510		J1P	FOUP
0426	511		TAD	DFSUM
0427	512		CLL	A10
0428	513		CIA	
0429	514		TAD	
0430	515		S2L	
0431	516		STA	
0432	517		DCA	
0433	518		ISZ	
0434	519		EPDIV	
0435	520		J1P	FOUP
0436	521		TAD	DFSUM
0437	522		CLL	A10
0438	523		CIA	
0439	524		TAD	
0440	525		S2L	
0441	526		STA	
0442	527		DCA	
0443	528		ISZ	
0444	529		EPDIV	
0445	530		J1P	FOUP
0446	531		TAD	DFSUM
0447	532		CLL	A10
0448	533		CIA	
0449	534		TAD	
0450	535		S2L	
0451	536		STA	
0452	537		DCA	
0453	538		ISZ	
0454	539		EPDIV	
0455	540		J1P	FOUP
0456	541		TAD	DFSUM
0457	542		CLL	A10
0458	543		CIA	
0459	544		TAD	
0460	545		S2L	
0461	546		STA	
0462	547		DCA	
0463	548		ISZ	
0464	549		EPDIV	
0465	550		J1P	FOUP
0466	551		TAD	DFSUM
0467	552		CLL	A10
0468	553		CIA	
0469	554		TAD	
0470	555		S2L	
0471	556		STA	
0472	557		DCA	
0473	558		ISZ	
0474	559		EPDIV	
0475	560		J1P	FOUP
0476	561		TAD	DFSUM
0477	562		CLL	A10
0478	563		CIA	
0479	564		TAD	
0480	565		S2L	
0481	566		STA	
0482	567		DCA	
0483	568		ISZ	
0484	569		EPDIV	
0485	570		J1P	FOUP
0486	571		TAD	DFSUM
0487	572		CLL	A10
0488	573		CIA	
0489	574		TAD	
0490	575		S2L	
0491	576		STA	
0492	577		DCA	
0493	578		ISZ	
0494	579		EPDIV	
0495	580		J1P	FOUP
0496	581		TAD	DFSUM
0497	582		CLL	A10
0498	583		CIA	
0499	584		TAD	
0500	585		S2L	
0501	586		STA	
0502	587		DCA	
0503	588		ISZ	
0504	589		EPDIV	
0505	590		J1P	FOUP
0506	591		TAD	DFSUM
0507				

0268	347	5253	44	NO
0270	350	1141	DFSM1	YES, REPLACE OLD
0271	351	7116	CLL FAP	
0272	352	3104	MAXEP	
0273	353	2157	FC4	
0274	354	5262	152	IS IT A MINUTE YET?
0275	355	0002	JIP	NO
0276	356	1363	10F	YES, PEARLITE LEVEL
0277	357	4866	THJ	AF01 A/V, CH.2
0278	360	3151	J15	
0279	361	0001	JCQ	
0280	362	5267	104	
0281	363	0002	JIP	
0282	364	7000	HOP	
0283	365	7000	HOP	
0284	366	7000	HOP	
0285	367	4571	STOP	
0286	368	7302	HLT	
0287	369	1104	MAXP	
0288	370	3151	TAB	
0289	371	3151	DATAPD	
0290	372	4571	STOP	
0291	373	7402	HLT	
0292	374	5242	HIP	
0293	375		HIP	
0294	376		HIP	
0295	377		HIP	
0296	378		HIP	
0297	379		HIP	
0298	380		HIP	
0299	381		HIP	
0300	382		HIP	
0301	383		HIP	
0302	384		HIP	
0303	385		HIP	
0304	386		HIP	
0305	387		HIP	
0306	388		HIP	
0307	389		HIP	
0308	390		HIP	
0309	391		HIP	
0310	392		HIP	
0311	393		HIP	
0312	394		HIP	
0313	395		HIP	
0314	396		HIP	
0315	397		HIP	
0316	398		HIP	
0317	399		HIP	
0318	400		HIP	
0319	401		HIP	

Page 2

0377	461	2165	LNXI.	152
0378	462	5240	JIP	JIP
0379	463	7100	CLL	MINLO
0380	464	1540	TAD	CIA
0381	465	7041	CIA	MINLO
0382	466	3540	DCA	MINLO
0383	467	7439	SCL	
0384	468	7091	IAC	MINHI
0385	469	1541	TAD	CIA
0386	470	7041	CIA	MINHI
0387	471	1341	DCA	MINHI
0388	472	7041	IAC	MINHI
0389	473	3341	DCA	MINHI
0390	474	7100	CLL	PPNLO
0391	475	1342	TAD	MINLO
0392	476	1340	TAD	PRDLO
0393	477	3342	DCA	SCL
0394	478	500	IAC	PRDHI
0395	479	7430	TAD	MINHI
0396	480	1343	DCA	PRDHI
0397	481	7001	IAC	BUFLOC
0398	482	1343	TAD	A16
0399	483	501	DCA	BUFLOC
0400	484	7430	TAD	A15
0401	485	1341	DCA	A15
0402	486	3343	TAD	MINI
0403	487	501	DCA	BUMP
0404	488	7430	TAD	LATEST
0405	489	1341	DCA	I
0406	490	3343	TAD	BUMP
0407	491	501	DCA	DCH
0408	492	7430	TAD	152
0409	493	1341	DCA	BUFN
0410	494	3343	TAD	SHUFL
0411	495	501	DCA	PRDLO
0412	496	7430	TAD	SPA
0413	497	1341	DCA	CIA
0414	498	3343	TAD	BSW
0415	499	501	DCA	RAL
0416	500	7430	TAD	X177
0417	501	1341	DCA	DFSCR
0418	502	3343	I	
0419	503	501		
0420	504	7430		
0421	505	1341		
0422	506	3343		
0423	507	501		
0424	508	7430		
0425	509	1341		
0426	510	3343		
0427	511	501		
0428	512	7430		
0429	513	1341		
0430	514	3343		
0431	515	501		
0432	516	7430		
0433	517	1341		
0434	518	3343		
0435	519	501		
0436	520	7430		
0437	521	1341		
0438	522	3343		
0439	523	501		
0440	524	7430		
0441	525	1341		
0442	526	3343		
0443	527	501		
0444	528	7430		
0445	529	1341		
0446	530	3343		
0447	531	501		
0448	532	7430		
0449	533	1341		
0450	534	3343		
0451	535	501		
0452	536	7430		
0453	537	1341		
0454	538	3343		
0455	539	501		
0456	540	7430		
0457	541	1341		
0458	542	3343		
0459	543	501		
0460	544	7430		
0461	545	1341		
0462	546	3343		
0463	547	501		

1540
MINLO.
MINHI.
PRDLO.
PRDHI.
SCNT.

0
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PAGE 3

GENERATE TIME CODE (OCTAL MINUTES)			
0485	*600	ENTER EACH 4 R'D'S IF TFLAG SET	
0486	C00T.	TCNTR	
0487		TOUT	
0488		NO	
0489	7402	TCNTR	
0490	601	TCNTR	
0491	2133	TOUT	
0492	5225	NO	
0493	602	TCNTR	
0494	603	TCNTR	
0495	1160	TOUT	
0496	604	TCNTR	
0497	3133	TOUT	
0498	605	TCNTR	
0499	2131	TOUT	
0500	5215	NO	
0501	606	TCNTR	
0502	607	TCNTR	
0503	1145	TOUT	
0504	608	TCNTR	
0505	610	TCNTR	
0506	2130	TOUT	
0507	5210	NO	
0508	611	TCNTR	
0509	2130	TOUT	
0510	5210	NO	
0511	612	TCNTR	
0512	7410	TOUT	
0513	613	TCNTR	
0514	3135	TOUT	
0515	614	TCNTR	
0516	5225	TOUT	
0517	615	TCNTR	
0518	6506	TOUT	
0519	616	TCNTR	
0520	1126	TOUT	
0521	617	TCNTR	
0522	7104	TOUT	
0523	620	TCNTR	
0524	3126	TOUT	
0525	621	TCNTR	
0526	7439	TOUT	
0527	622	TCNTR	
0528	1127	TOUT	
0529	623	TCNTR	
0530	1176	TOUT	
0531	624	TCNTR	
0532	3134	TOUT	
0533	625	TCNTR	
0534	1134	TOUT	
0535	626	TCNTR	
0536	7500	TOUT	
0537	627	TCNTR	
0538	6507	TOUT	
0539	7001	TCODE1	
0540	630	TCODE1	
0541	7001	TCODE1	
0542	631	TCODE1	
0543	3134	TCODE1	
0544	632	TCODE1	
0545	5609	TCODE1	
0546	633	TCODE1	
0547	5609	TCODE1	
0548	634	TCODE1	
0549	5609	TCODE1	
0550	635	TCODE1	
0551	5609	TCODE1	
0552	636	TCODE1	
0553	5609	TCODE1	
0554	637	TCODE1	
0555	5609	TCODE1	
0556	638	TCODE1	
0557	5609	TCODE1	
0558	639	TCODE1	
0559	5609	TCODE1	
0560	640	TCODE1	
0561	5609	TCODE1	
0562	641	TCODE1	
0563	642	TCODE1	
0564	643	TCODE1	
0565	644	TCODE1	
0566	645	TCODE1	
0567	646	TCODE1	
0568	647	TCODE1	
0569	648	TCODE1	
0570	649	TCODE1	
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0585	664	TCODE1	
0586	665	TCODE1	
0587	666	TCODE1	
0588	667	TCODE1	
0589	668	TCODE1	
0590	669	TCODE1	
0591	670	TCODE1	
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0594	673	TCODE1	
0595	674	TCODE1	
0596	675	TCODE1	
0597	676	TCODE1	
0598	677	TCODE1	
0599	678	TCODE1	
0600	679	TCODE1	
0601	680	TCODE1	
0602	681	TCODE1	
0603	682	TCODE1	
0604	683	TCODE1	
0605	684	TCODE1	
0606	685	TCODE1	
0607	686	TCODE1	
0608	687	TCODE1	
0609	688	TCODE1	
0610	689	TCODE1	
0611	690	TCODE1	
0612	691	TCODE1	
0613	692	TCODE1	
0614	693	TCODE1	
0615	694	TCODE1	
0616	695	TCODE1	
0617	696	TCODE1	
0618	697	TCODE1	
0619	698	TCODE1	
0620	699	TCODE1	
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0622	701	TCODE1	
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0832	911	TCODE1	
083			

0539	652	22.40	ISZ	STORES	NO, RETURN +1
0540	653	5640	JMP	STORES	YES, WHICH FLD?
0541	654	1124	TAD	FLDFLG	
0542	655	7440	SZA		
0543	656	5640	JMP	STORES	FLD 1, RTRN & END
0544	657	2124	ISZ	FLDFLG	FLD 0, SWITCH TO FLD 1
0545	670	7240	STA		
0546	671	3017	DCA	DATA[P	RESET DATA PTR TO TOP
0547	672	22.40	ISZ	STORES	
0548	673	5640	JMP	STORES	RTRN +1
0549	0550				
0551					
0552					
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0562					
0563					

RECORDED MEMORY

MAXIMAL EPOCH ACTIVITY SCORE AND
LUTT LEVEL FOR EACH MINUTE ARE
STORED IN ALTEPIATE MEMORY LOC'S
FROM LOC. 700 TO 5777 (FLD 0)
AND 10000 TO 15777 (FLD 1)

*700

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